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Hlebovy

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(54) **COMPOSITE PRESSURE VESSEL WITH HEAT EXCHANGER**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **B23P 15/00**

(52) **U.S. Cl.** **29/890.06**; 29/890.03; 264/220

(58) **Field of Search** 29/840.03, 840.06; 264/220, 219, 271.1, 275

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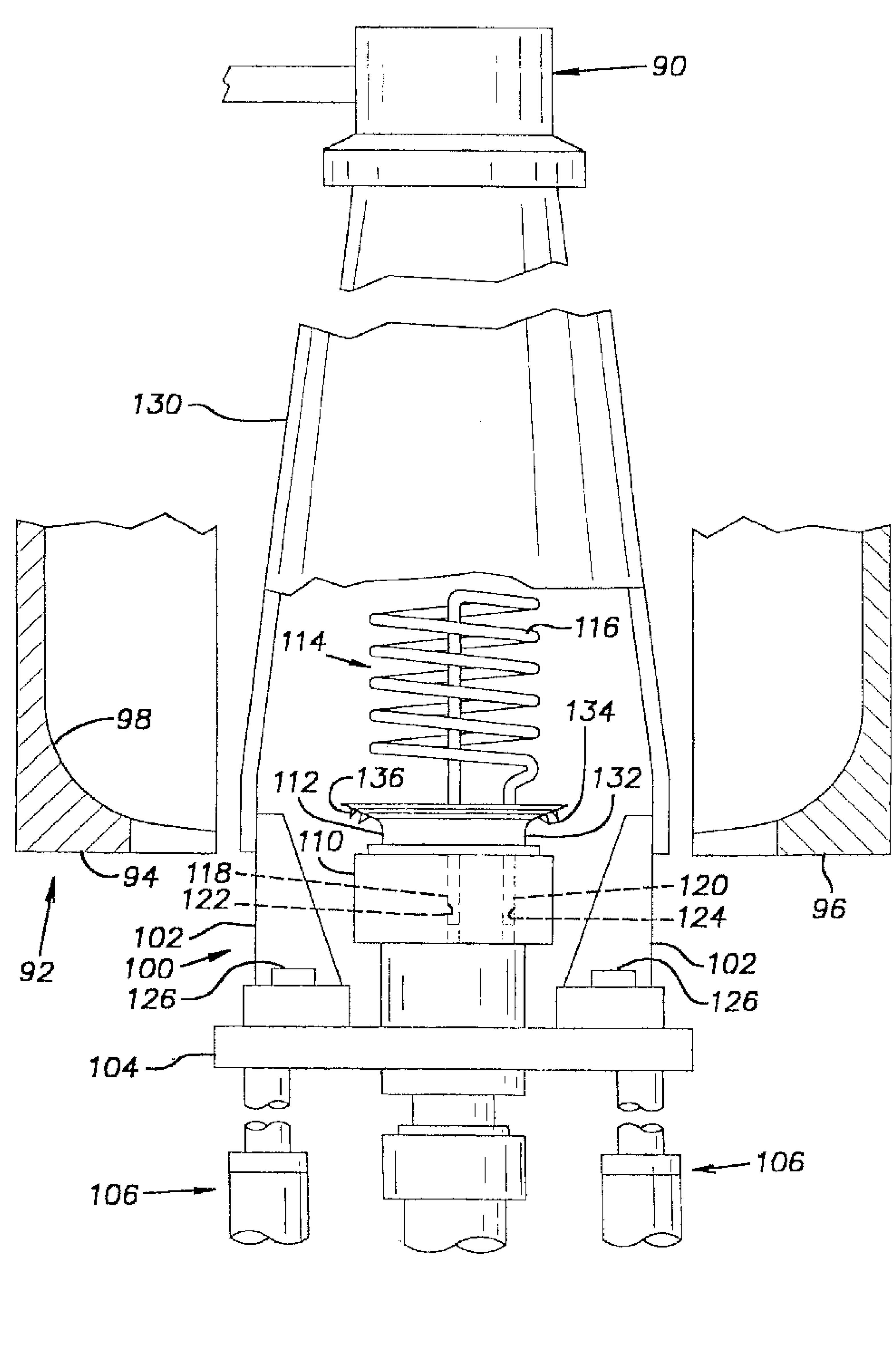
(57) **ABSTRACT**

A seamless plastic pressure vessel having a heat exchanger encased therein is disclosed. The pressure vessel is a unitary seamless wall and the wall surrounds a heat exchanger unit comprising a length of hollow tubing having ends retained in a mounting fitting. The pressure vessel may be formed by a rotational casting or blow molding technique.

6 Claims, 4 Drawing Sheets



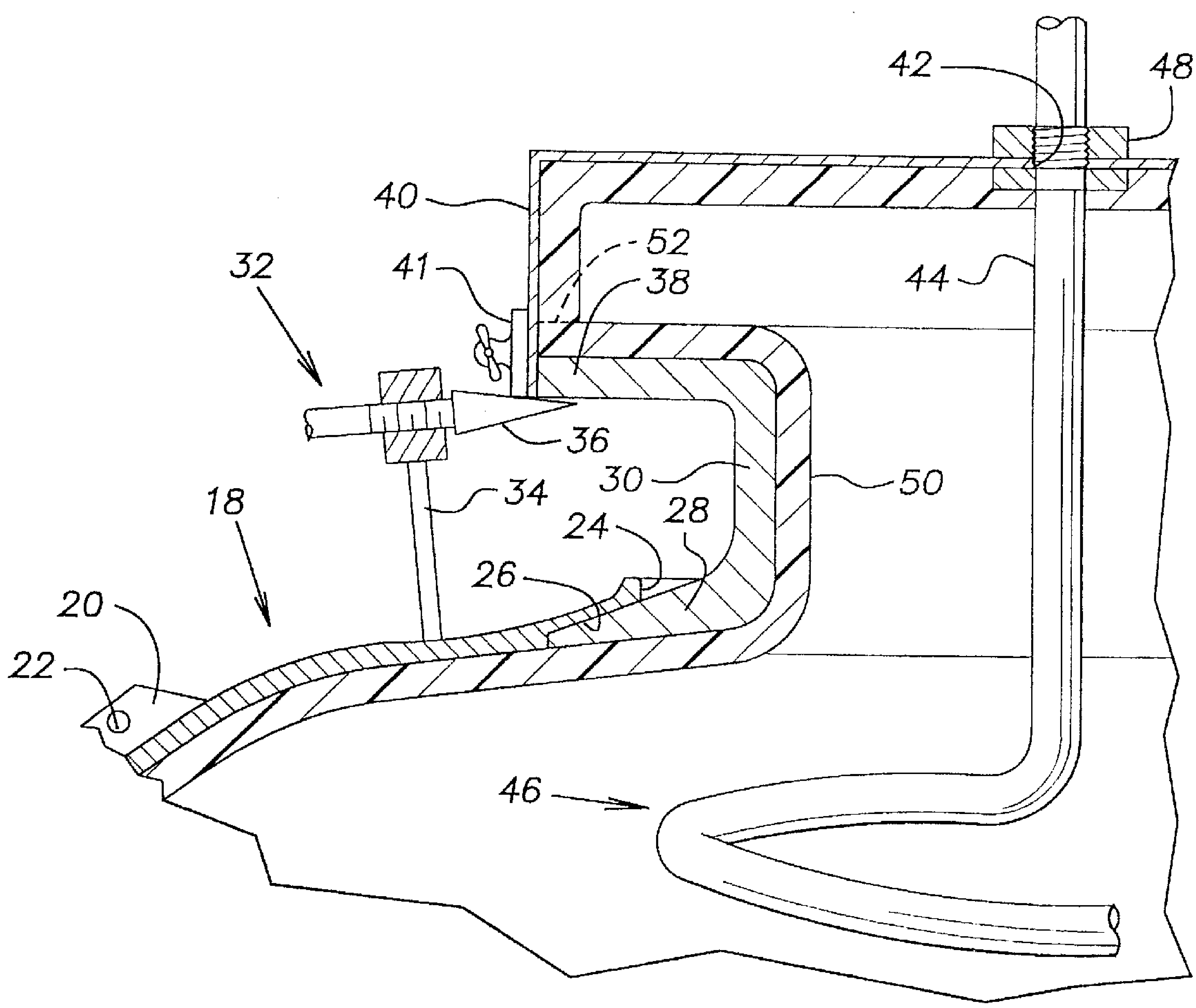


FIG. 1

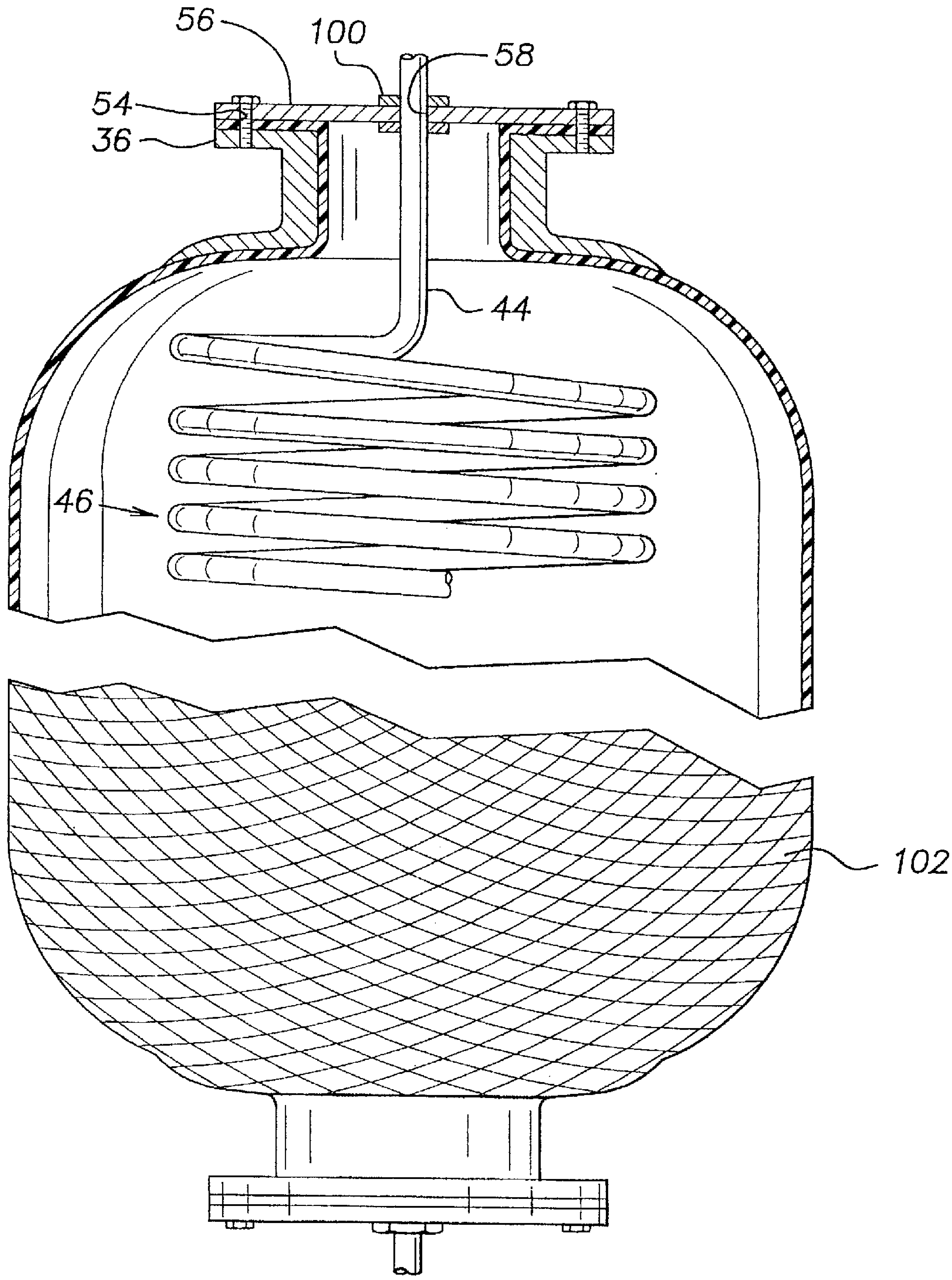


FIG. 1A

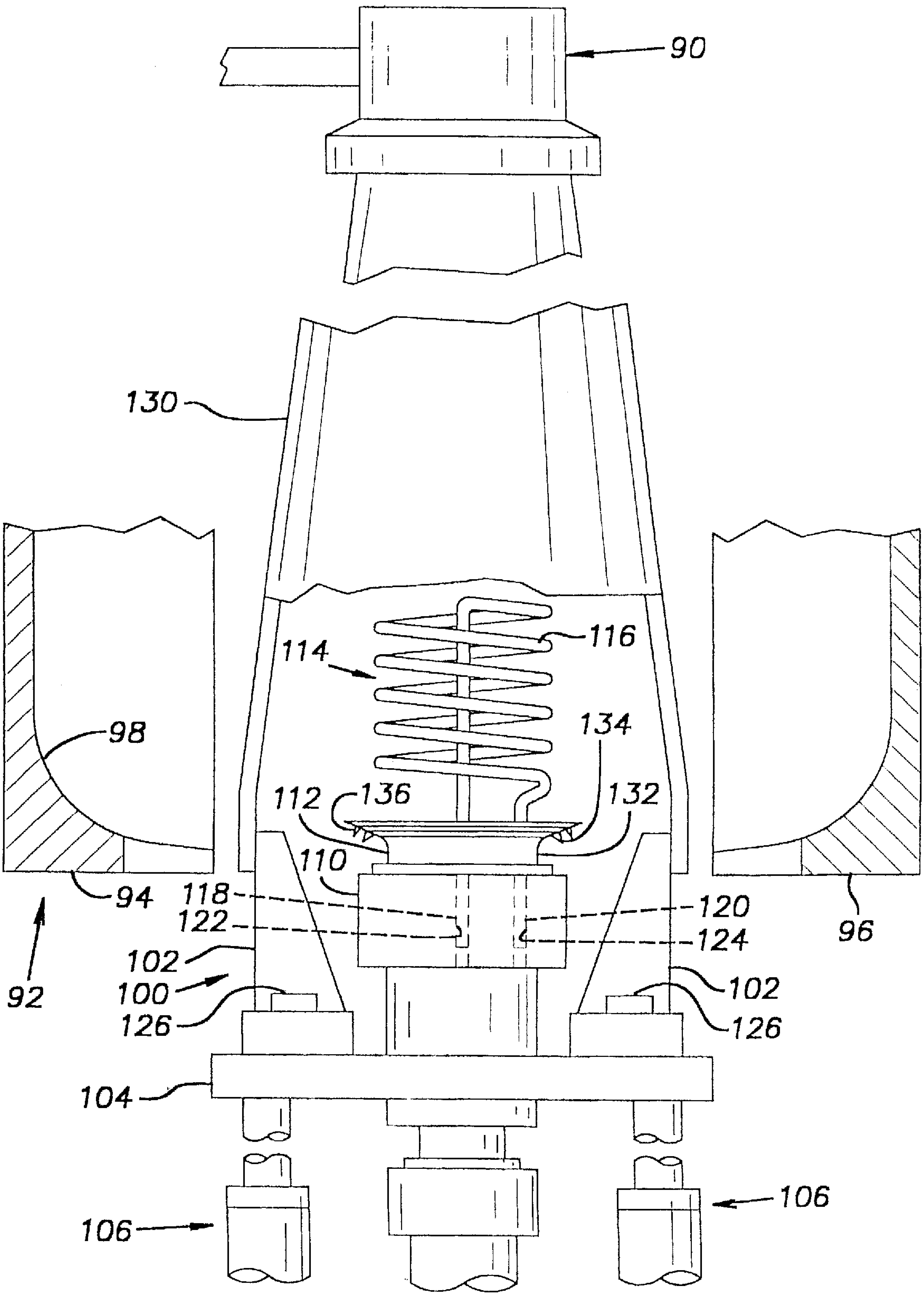

90
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Fig.2

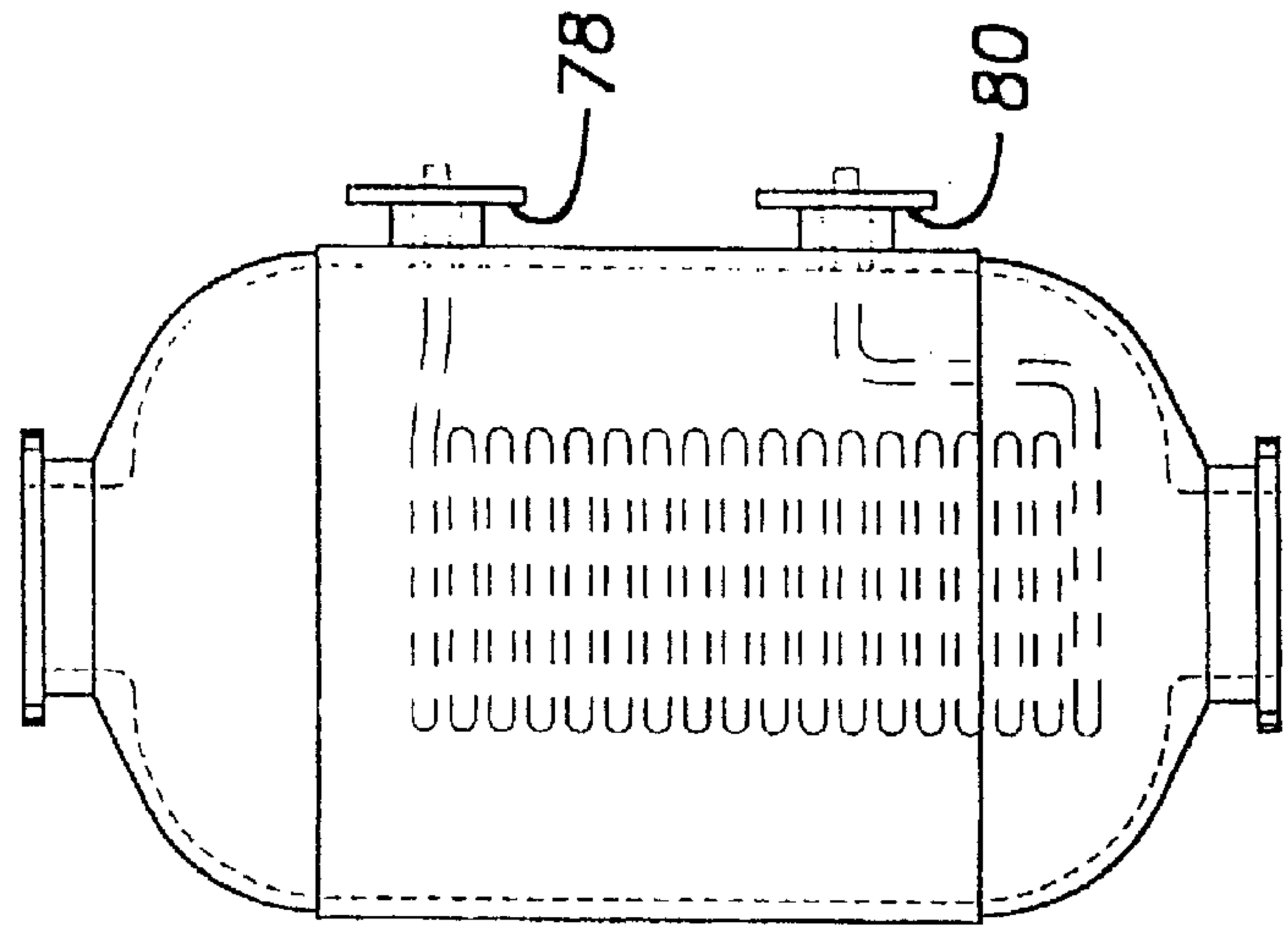

Fig.5

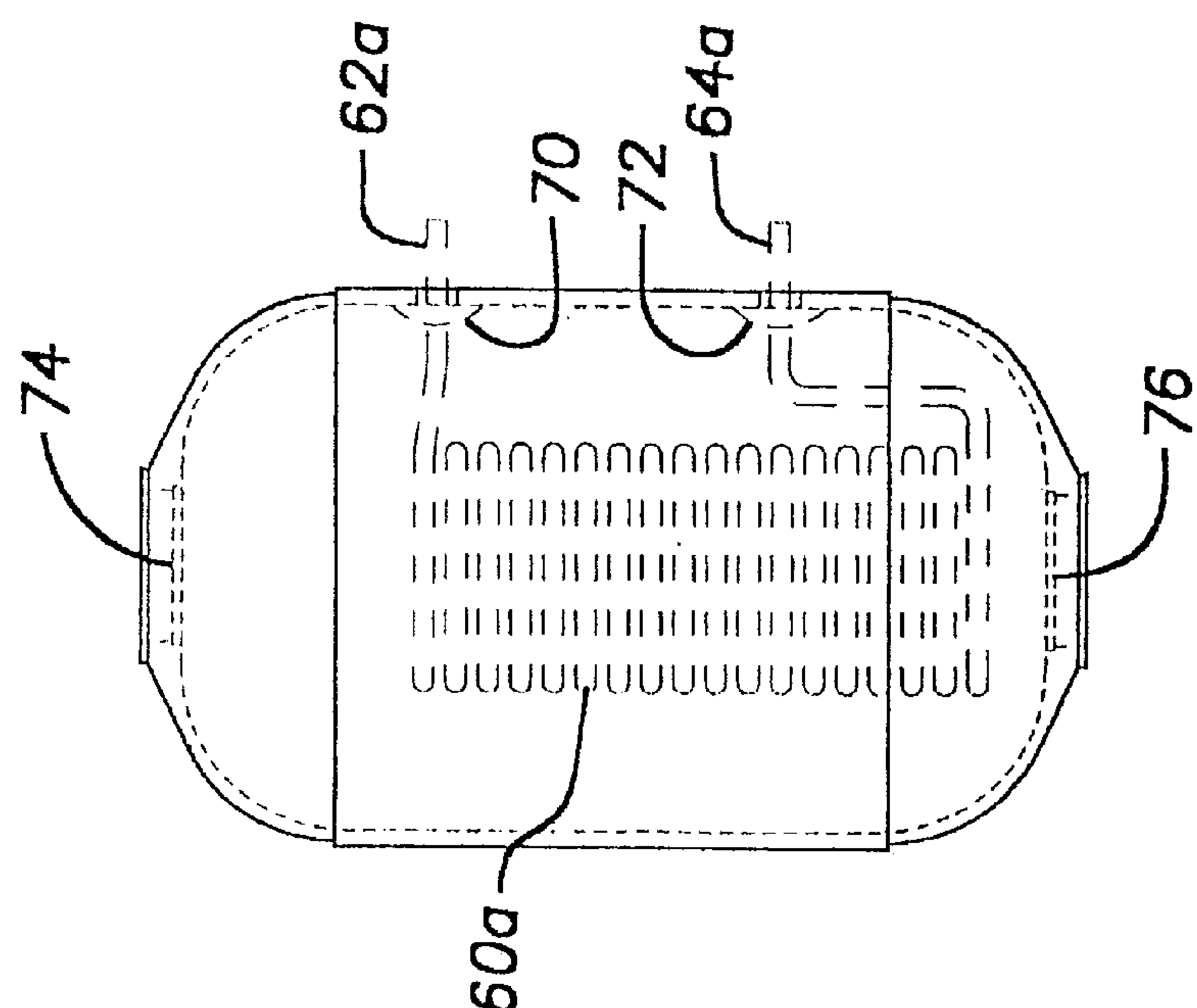

Fig.4

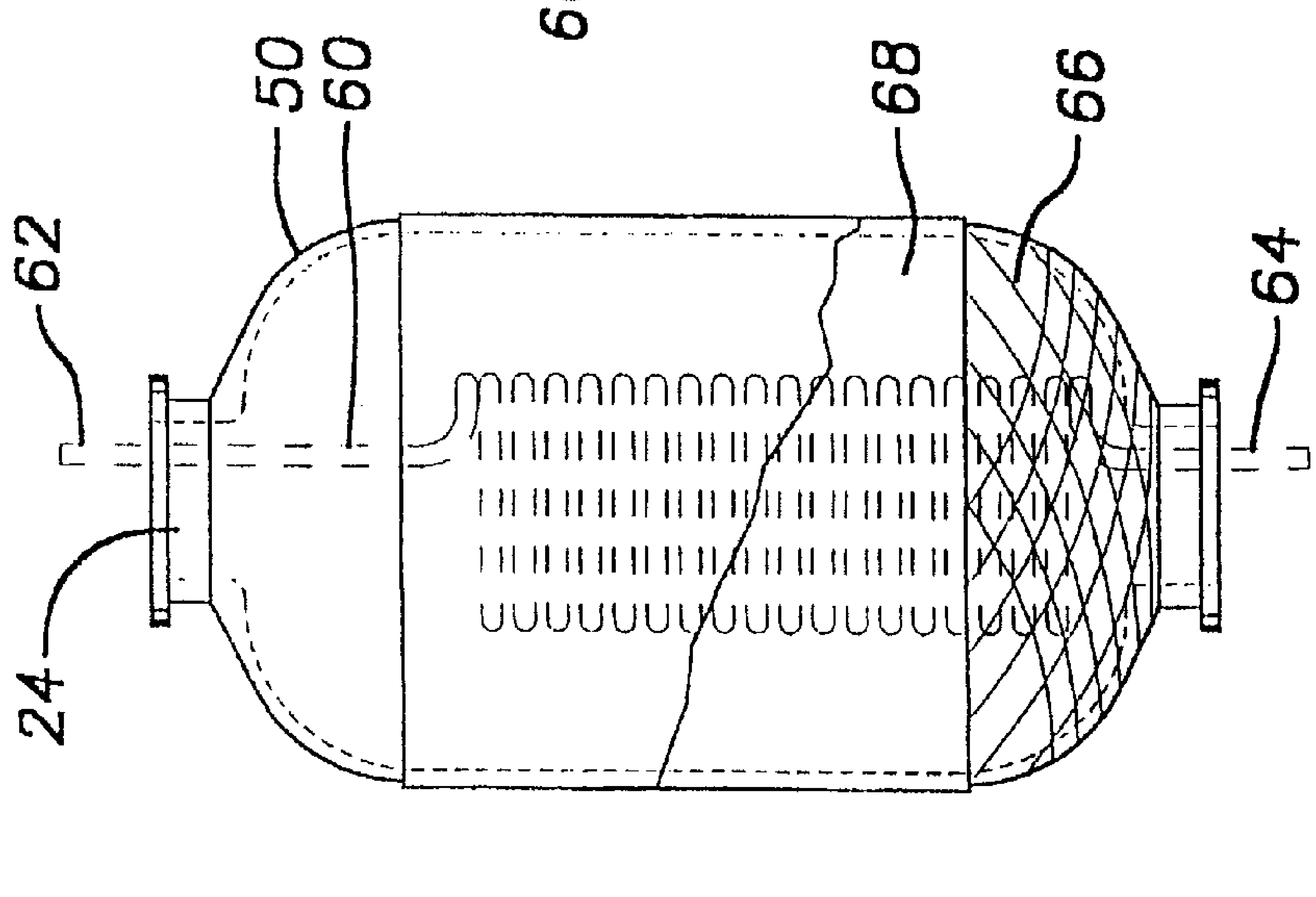

Fig.3

COMPOSITE PRESSURE VESSEL WITH HEAT EXCHANGER

This application claims the benefit of U.S. Provisional Application No.: 60/045,092, filed Apr. 29, 1997.

This invention relates to heat exchangers and, more particularly, to a seamless pressure vessel which encapsulates a heat exchanger unit.

Containers surrounding heat exchanger units are typically assembled around the heat exchanger unit to encapsulate the same. A relatively large access opening must be provided in the container to accommodate the insertion of the heat exchanger. Since many heat exchangers, such as hot water heaters, require small access openings for the heat exchanger fluid piping and piping for the main body of fluid, additional seaming on the container results in potential areas of weld corrosion in the case of metallic containers or areas of stress concentration which may result in the rupture of adhesively bonded plastic containers.

SUMMARY OF THE INVENTION

This invention provides a seamless plastic pressure vessel which encapsulates a heat exchanger unit. According to this invention the pressure vessel may be manufactured by a rotational casting technique of the type set forth in U.S. Pat. No. 4,705,468 or a blow molding technique of the type set forth in U.S. Pat. No. 4,589,563.

In general, the manufacturing technique involves encapsulating a heat exchanger unit such as a helically coiled tube in a hollow, seamless plastic casing. The heat exchanger unit is positioned within a mold which defines a mold cavity having a wall which is adapted to define and form a seamless plastic envelope around the heat exchanger unit. A thermoplastic molding composition is provided on the wall to encapsulate the unit and provide the seamless pressure vessel.

One technique involves rotationally casting the seamless plastic envelope around the heat exchanger unit by mounting an inlet tube portion and an outlet tube portion of the heat exchanger unit in mounting fittings so that a heat exchanger coil is within the mold cavity during the molding operation and remains within the molded plastic envelope after the molding operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a fragmentary elevational view, partly in section, of a rotational casting mold which is adapted to be mounted in the casting arm of the machine for producing a pressure vessel according to one aspect of this invention;

FIG. **1***a* is a fragmentary elevational view, partly in section, of a rotationally cast pressure vessel having a heat exchanger mounted therein according to one aspect of this invention;

FIG. **2** is an elevational view, partly in section, of blow molding apparatus, showing the molding apparatus in a parison receiving position with a heat exchanger unit in position to be encapsulated;

FIG. **3** is an elevational view, partly in section, of a pressure vessel having a heat exchanger mounted therein according to a further aspect of this invention;

FIG. **4** is a pressure vessel similar to the vessel illustrated in FIG. **3**; and

FIG. **5** is a view similar to FIGS. **3** and **4** illustrating a pressure vessel in accordance with a still further aspect of this invention.

DETAILED DESCRIPTION OF THE INVENTION

According to one aspect of the invention a seamless plastic pressure vessel having a heat exchanger unit encapsulated therein is produced by a conventional rotational casting molding operation as is illustrated in FIG. **1**. This casting technique is set forth in greater detail in U.S. Pat. No. 4,705,468, the subject matter of which is incorporated herein by reference. The conventional rotational casting molding operation consists of placing a plastic molding compound in finely divided form inside a hollow mold. The mold is then heated to a temperature above the melting point of the plastic and, at the same time, the mold is rotated about orthogonal axes. The powdered plastic inside the mold is heated by the heat transferred from the mold surface and sticks to the inner mold surface. Heating is continued for a sufficient length of time for complete melting or fusing of all of the plastic particles, and to permit bubbles to be released from the molten plastic. The thickness of the plastic article is determined by the amount of plastic placed within a given mold.

In FIG. **1** the molding apparatus comprises a mold arm assembly which includes upper and lower frame members rotated by a mechanism (not shown) about orthoganal axes. A rotational casting mold **18** is mounted on the casting arm of a rotational casting machine.

The mold **18** is generally cylindrical having a cylindrical body portion closed by oblate ellipsoidal end portions and is formed by two mold halves each having mating flanges **20**. One of the flanges on a mold half is provided with pins (not shown) which register through apertures **22** in the other flange. If desired, quick connect clamps (not shown) may be provided to secure the mold halves together. The mold halves close and register to define an axial opening **24** therein. A circular recess **26** surrounds the opening **24** and receives a radially outwardly extending flange portion **28** of an outlet fitting **30**. The fitting **30** may be metal or plastic.

The fitting **30** is retained in its illustrated position by a series of tapered pins **32** which are threaded through a corresponding series of rigid vertical posts **34**. A tapered portion **36** of the pin **32** engages, the lower edge of an upper flange **38** as the pin **32** is treadedly advanced to draw the portion **28** into snug engagement with the recess **26**.

A cap **40** surrounds the periphery of the flange **38** and has an axial opening **42** therein which receives an axially extending tube **44** of a coiled tube heat exchanger unit **46**. The cap **40** is securely maintained by a clamping band **41**. The other end of the heat exchanger tubing may extend axially to an identical fitting arrangement (not shown) at the other end of the mold or the tubing may extend upwardly to parallel the tube **44** and to extend through another opening in the cap **40**. A nut **48** secures the tube **44**. Additional access fittings (not shown in FIG. **1**, but illustrated in FIGS. **4** and **5**) may be provided in the side wall of the mold and may be initially attached thereto in the manner illustrated in FIG. **1**.

To mold a seamless pressure vessel having a heat exchanger unit encapsulated therein as illustrated in FIGS. **3** through **5**, a charge of powdered plastic resin is placed within one of the mold halves and the mold is assembled to its fitting and mounted on the rotational casting arm.

A predetermined amount of powdered thermoplastic resin is placed in the mold to provide sufficient molding compound to coat the entire inside surface of the mold and the fittings to a predetermined thickness. After the powder is put into the mold and the mold is assembled, the mold is rotated about its orthogonal axes, while the mold is heated to a predetermined temperature which will melt the thermoplastic resin. This operation is conducted within a closed oven which encloses the mold and the rotating arm. The application of heat to the mold causes the resin to melt or fuse, and the rotation of the mold about the orthogonal axes causes the liquid resin to uniformly coat the interior of the mold cavity and the interior of the fittings **30** so that a liner **50** is formed having a predetermined uniform thickness. After a predetermined time at the heating station, the arm is transferred to a cooling station, where the thermoplastic resin cools to a solid material. At a further operational station the mold is disassembled and the liner, with its fittings **30**, is removed from the mold.

The liner **50** and its fitting **30** are removed from the mold as a unit. After the cap **30** is removed by removing the band **41** and the nut **48**, the liner **50** is trimmed at the plane indicated by the dotted line **52**. The trimmed material is also removed from the tube **44**.

Referring now to FIG. **1***a,* the pressure vessel is assembled by boring a series of fastener receiving holes **54** in the flange **38** and providing a closure plate **56**. The plate **56** has a central aperture **58** which receives the tube **44** and the tube **44** is fastened by a nut **100**. A similar closure arrangement is provided at the other end of the pressure vessel and the tank may be provided with a filament wound reinforcement **102**.

As may be seen in FIGS. **3** through **5** a rotational casting procedure may be employed to produce a seamless pressure vessel having a variety of heat exchanger configurations therein.

In FIG. **3** the seamless pressure vessel includes the liner **50** and the fitting **24** molded thereto. A tubular heat exchanger unit **60** extends through and is supported by the fittings **24**. The heat exchanger **60** is a helically coiled pipe having inlet and outlet tubes **62** and **64** so that a heat exchanging fluid may be introduced into the tubing to exchange heat with a fluid contained in the pressure vessel. The fluid in the pressure vessel may be introduced to and withdrawn from the vessel by tubing fittings (not shown) provided in the fittings **24**.

The liner **50** may be reinforced by a helical winding **66** and by a level or hoop winding **68** in accordance with prior art techniques.

FIG. **4** illustrates a heat exchanger unit **60***a* having inlet and outlet ends **62***a* and **64***a* entering and exiting the liner **50** through its cylindrical side wall. Molded in plastic fittings **70** and **72** are provided in the side wall of the tank and axially aligned plastic fittings **74** and **76** are provided as mounting fittings for tubing (not shown) to convey fluid to and from the interior of the pressure vessel.

FIG. **5** illustrates an arrangement similar to the arrangement shown in FIG. **4**. In FIG. **5** flanged aluminum fittings **78** and **80** are provided in the side wall of the tank while flange aluminum fittings **82** and **84** are provided at the ends of the tank for mounting tubing therethrough.

According to another aspect of the present invention the seamless pressure vessel may be fabricated by a blow molding technique as is illustrated in FIG. **2**. In FIG. **2** there is illustrated an apparatus which includes a conventional parison extrusion head **90**, a segmented hollow mold **92** which includes a pair of mold halves **94** and **96** having an inside surface **98** which defines the outside surface of the seamless plastic tank to be molded, and a parison stretching assembly **100**.

The assembly **100** includes a plurality of curved plates **102**. The plates are arranged on a first platform **104** mounted on rod and piston assembles **106**. A rod **108** disposed

through an appropriate opening in the platform **104** supports a second platform **110**. The platform **110** supports a heat exchanger unit mounting fitting **112** thereon. The mounting fitting **112** is provided with a tubular heat exchanger **114** which comprises a helically coiled tubing **116** having inlet and outlet tubing ends **118** and **120** which are molded into the fitting **112** and which project into openings **122** and **124** in the platform **110**.

The rod and piston assembles **106** are adapted to move the platform **104** and the plates **102** from a lower position below the platform **110** and through an upper position above the platform **110** so that the plates may be turned radially inwardly about pivot pins **126** to form a protective dome over the heat exchanger coil **114**. This apparition is explained in greater detail in U.S. Pat. No. 4,589,563. Pneumatically operated controls rods (not shown) are used to pivot the plates **102** and about the pins **126**.

At the beginning of the molding process the platform **104** is raised and the plates **102** are closed over the coil **116**. A tube or parison is extruded downwardly by the extrusion head **90** and is in a flowable plastic state. The extrusion rate is inversely proportional to the extruded wall thickness of the parison so that a fast extrusion rate produces a relatively thin wall and a slow rate produces a relatively thick wall.

When the parison reaches the plates **102** which envelope the tube **116** the plates separate as they move downwardly by retracting the platform **104** so that the parison **130** is expanded outwardly and envelopes the coil **116**. This position is shown in FIG. **2**. The mold segments **96** are moved radially inwardly while the plates are lowered by the platform **104** so that the mold surface **98** surrounds a major portion of the parison and pinches off the top of the parison and pinches a bottom portion of the parison against a neck **132** and flange portion **134** of the fitting **112**. Ridges **136** may be provided on the flange **134** so that the flange may interlock with the parison as it is squeezed around the fitting **112**.

After the mold segments are brought together, air is admitted to the parison through a passageway (not shown) in the extrusion head **90**. The parison is thereby expanded until it conforms to the mold surface **98**. After a suitable cooling period, the mold segments **94** and **96** are opened and the molded pressure vessel is removed from the table **110**.

Although the preferred embodiments of this invention have been shown and described, it should be understood that various modifications and rearrangements of the parts may be resorted to without departing from the scope of the invention as disclosed and claimed herein.

What is claimed:

1. A method of manufacturing a seamless pressure vessel which encapsulates a heat exchanger unit comprising the steps of providing a tubular heat exchanger unit, positioning said unit within a mold which defines a mold cavity having a wall which is adapted to define and form a seamless plastic envelope around said unit, molding a thermoplastic molding composition on said wall to encapsulate said unit and provide a seamless pressure vessel, and removing said seamless pressure vessel and its encapsulated heat exchanger unit from said mold.

2. A method according to claim **1** wherein said tubular heat exchanger unit includes an inlet tube and an outlet tube and said method further comprises the steps of mounting an inlet tube portion and an outlet tube portion of said heat exchanger within said mold cavity by mounting said fittings on said mold wall so that said heat exchanger is within said mold cavity and so that said thermoplastic molding composition is joined to said fitting.

3. A method according to claim **1** wherein said thermoplastic molding composition is molded on said wall by a rotational casting technique.

4. A method according to claim **1** wherein said thermoplastic molding composition is molded on said wall by a blow molding technique.

5. A method of manufacturing a seamless pressure vessel which encapsulates a heat exchanger unit comprising the steps of providing a heat exchanger unit, positioning said heat exchanger unit in a mounting fitting, providing a hollow mold having an opening therein and having a mold cavity surface conforming to the outside surface of the pressure vessel, removably positioning said mounting fitting in said openings so that at least a portion of said fitting extends into said hollow mold and so that said heat exchanger unit is spaced from the mold cavity surface, providing a plastic molding composition in said mold cavity in an amount sufficient to coat said heating mold about orthogonal axes to coat said mold cavity surface and to fuse to said portion of said fitting, cooling said mold to solidify said molding composition into a seamless pressure vessel, and removing said vessel from said mold.

6. A method of manufacturing a seamless pressure vessel which encapsulates a heat exchanger unit comprising the steps of providing a heat exchanger unit, positioning said heat exchanger unit in a mounting fitting, said mounting fitting having a neck portion and a radial flange portion extending therefrom, providing a segmented hollow mold having mold segments translatable from an open position to a closed position defining a mold cavity surface conforming to the outside surface of the pressure vessel positioning said mounting fitting and said heat exchanger unit on a platform positioned between said mold segments, hot extruding a plastic parison downwardly and in axial alignment with said mounting fitting and said heat exchanger unit and said neck portion of said fitting, advancing said mold segments toward each other to pinch off a top portion of said parison, to mold said parison against said flange and neck portions of said fitting, and to define said mold cavity, admitting a pressurized gas to the interior of said parison to force said parison against said mold cavity, cooling said plastic, and removing the pressure vessel from said mold.

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